

# CAAP Quarterly Report

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Contract Number: *DTPH5615HCAP02*

Prepared for: *US DOT - PHMSA*

Project Title: *"Understanding and Mitigating the Threat of AC Induced Corrosion on Buried Pipelines"*

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For quarterly period ending: *December 30, 2016*

## **Business and Activity Section**

### **(a) Generated Commitments –**

Travel - DOT PHMSA R&D Forum, Cleveland OH, Nov 16 2016.

Materials and supplies – chemicals, small parts, machine shop work to fabricate samples

### **(b) Status Update of Past Quarter Activities –**

#### Summary:

During this quarter we made progress on several milestones including:

*Overprotection and AC* - Pipelines with higher AC pipe to soil potentials will have higher corrosion rates. The only apparent way to mitigate this effect is by lowering the CP potential such that  $|E_{\text{corr}} - E_{\text{CP}}|$  is greater than the AC potential drop across the electrochemical interface at the holiday. However, this can come with the negative impact of "overprotection." To investigate this phenomena, long term lab experiments at potentials more negative than the CP potential were initiated to identify a region of "over protection." In these experiments we are investigating potentials between -0.850V and -1.20V vs. CSE, the practical limit for off potentials in the field.

*Field Studies* - A meeting was held with Marathon and Mears to plan the field studies that will begin Spring 2017. Experiments at the Mears CP test facilities will be conducted on samples electrically bonded to the test pipeline as well as monitoring of man-made holidays on a buried pipe with an impressed AC. Samples will be evaluated with varying surface preparation such as scale thickness will be exposed to various AC signals of known (controlled) magnitude. Corrosion rate data including weight loss and thickness measurements will be compared with real time measurements of the system impedance during the exposure period.

*AC and SCC* - As the AC potential has both anodic and cathodic parts, if the cathodic peak potential is sufficiently below the reversible hydrogen potential than production of atomic hydrogen at the surface of a holiday will occur. Hydrogen uptake can lead to embrittlement (e.g. SCC / environmental fracture). In this quarter we began setting up the experiments that will be needed to determine the susceptibility of pipeline steel to environmental fracture during exposure to AC. Specifically, tensile test will measure changes in elongation, modulus, tensile stress and ultimate tensile strength as a function of combinations of applied AC and CP potentials. In addition, hydrogen permeation

experiments will measurement of hydrogen uptake as a function of applied AC and CP potentials. Each of these studies was initiated in FY17 Q1.

Finally, we participated in the DOT PHMSA R&D Forum November 16-17. Andrew Moran presented a student poster and Scott Lillard gave a brief PowerPoint overview of the work. Co-PI Stephen Ernst (Marathon Pipeline) was also in attendance.

#### Experimental details:

- AC corrosion experiments on X65 steel in NS4 soil simulant:
  - Performed long-term (6 week) potentiostatic experiments at very low CP potentials of -1.0V and -1.2V vs. SCE. (-1070mV and -1270mV vs. CSE) and a high impressed AC potential of 3Vrms between the working electrode and reference electrode.
  - Magnesium Sulfate and Calcium Chloride were removed from the NS4 solution to measure the effect of bare steel samples without scale development.
  - Periodic EIS measurements were taken to determine the capacitance over time of the electrochemical interface as well as changes in solution resistance.
  - AC and DC current measurements were made and will be compared to weight loss measurements.
- AC field measurements on buried pipeline:
  - During a meeting with Marathon Pipe Line (Kyle Platt, Steve Ernst), Mears Group, Inc. (Kevin Garrity, Dan Wagner), and The University of Akron (Scott Lillard, Andrew Moran) on Dec. 2<sup>nd</sup>, 2016, the plans for in-field measurements of test coupons were developed.
  - Tests will be performed at the Mears LaGrange, Texas testing facility and at a testing facility in Rosebush, Michigan. Rosebush: Spring 2017; LaGrange Summer 2017.
  - Tests will include AC and DC measurements as well as weight loss analysis of installed test coupons. The induced AC voltage on buried pipelines will be controlled to determine its effect on corrosion rate. Critical parameters such as pH, moisture content, soil resistivity, and soil ion content will be tracked at each test coupon site.
  - Subsequent to this meeting we have begun to procure the samples and testing equipment needed for the the Rosebush experiments.
- AC induced SCC / Hydrogen Embrittlement:
  - An MS graduate student, Lizeth Sanchez Camacho joined the project since September 2016.
  - Lizeth has performed extensive literature reviews on AC induced corrosion and environmental fracture while taking three classes. Based on this literature review, a hydrogen permeation cell is being designed for laboratory experiments.
  - Slow strain rate frame for stress corrosion cracking (SCC) testing has been set up and calibrated. Carbon steel tensile coupons have been procured and ready for testing and the student is becoming familiar with electrochemical testing and mechanical testing in the laboratory.

#### **Description of any Problems/Challenges –**

- None to report

#### **(c) Planned Activities for the Next Quarter –**

- Planning and exploratory experiments: Field studies and SCC.